Front End Spectroscopy ASIC for Germanium Detectors

Completed Technology Project (2016 - 2018)

Project Introduction

Large-area, tracking, semiconductor detectors with excellent spatial and spectral resolution enable exciting new access to soft (0.2-5 MeV) gamma-ray astrophysics. The improvements from semiconductor tracking detectors come with the burden of high density of strips and/or pixels that require high-density, low-power, spectroscopy quality readout electronics. CMOS ASIC technologies are a natural fit to this requirement and have led to high-quality readout systems for all current semiconducting tracking detectors except for germanium detectors. The Compton Spectrometer and Imager (COSI), formerly NCT, at University of California Berkeley and the Gamma-Ray Imager/Polarimeter for Solar flares (GRIPS) at Goddard Space Flight Center utilize germanium cross-strip detectors and are on the forefront of NASA's Compton telescope research with funded missions of long duration balloon flights. The development of a readout ASIC for germanium detectors would allow COSI to replace their discrete electronics readout and would enable the proposed Gamma-Ray Explorer (GRX) mission utilizing germanium strip-detectors. We propose a 3-year program to develop and test a germanium readout ASIC to TRL 5 and to integrate the ASIC readout onto a COSI detector allowing a TRL 6 demonstration for the following COSI balloon flight. Our group at NRL led a program, sponsored by another government agency, to produce and integrate a cross-strip silicon detector ASIC, designed and fabricated by Dr. De Geronimo at Brookhaven National Laboratory. The ASIC was designed to handle the large (>30 pF) capacitance of three 10 cm^2 detectors daisy-chained together. The front-end preamplifier, selectable inverter, shaping times, and gains make this ASIC compatible with a germanium cross-strip detector as well. We therefore have the opportunity and expertise to leverage the previous investment in the silicon ASIC for a new mission. A germanium strip detector ASIC will also require precise timing of the signals at the anode and cathode of the device to allow the depth of the interaction within the crystal to be determined. Dr. De Geronimo has developed similar timing circuits for CZT detector ASICs. Furthermore, the timing circuitry of the ASIC is at the very end of the analog section, simplifying and mitigating risks in the redesign. In the first year, we propose to tweak the gain settings and to add timing to the silicon ASIC to match the requirements of a germanium detector. The design specifications of the ASIC will include advice from our collaborators Dr. Boggs from COSI and Dr. Shih from GRIPS. By using a master ASIC designer to integrate his proven front-end and back-end with only minor modifications, we are maximizing the probability of success. NRL has a commercial cross-strip germanium detector with 30 pF of capacitance per strip, including the flex circuit from the detector to the outside of the cryostat. The COSI and GRIPS detectors have a similar capacitance per strip on the outside of their mechanically cooled cryostat. The second year of the program will be devoted to testing the newly fabricated germanium cross-strip ASIC with the NRL germanium detector. At the end of the second year, NASA will have a TRL 5 ASIC for germanium detectors, allowing future missions, including COSI, GRX, and GRIPS, to operate within

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics Research and Analysis

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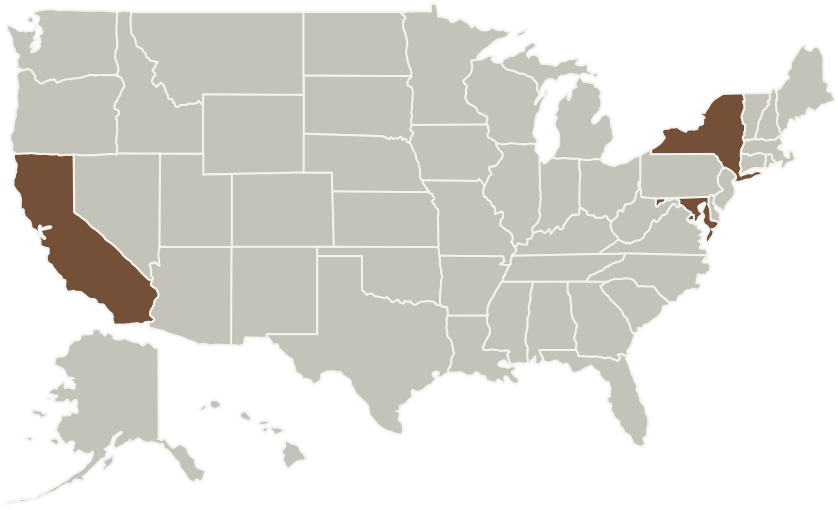
their thermal and electrical envelopes. At the end of the third year, a detector on COSI will be instrumented with the new ASIC allowing for a TRL 6 demonstration during the following COSI balloon flight.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Naval Research Laboratory(NRL)	Supporting Organization	US Government	Washington, District of Columbia

Primary U.S. Work Locations	
California	District of Columbia
Maryland	New York

Project Management

Program Director:
Michael A Garcia

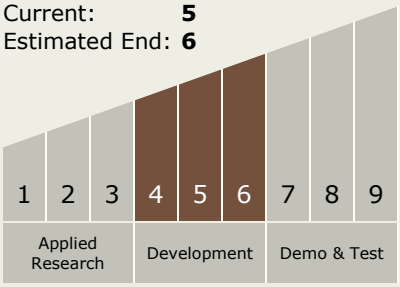
Program Manager:
Dominic J Benford

Principal Investigator:
Eric A Wulf

Co-Investigators:
Albert Y Shih
Steven E Boggs
Jill P Dahlburg
Gianluigi De Geronimo
J Eric Grove
Bernard Phlips

Technology Maturity (TRL)

Start: **4**
Current: **5**
Estimated End: **6**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors

Continued on following page.

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Technology Areas *(cont.)*

- TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System